

Hand Wrist Bone Identification Using Quadrant Ballon Snake

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Abstract

In this research, hand wrist bone Identification for human forensic is discussed. Hand wrist bone is one of the effective methods used in the forensic science for age identification. There are four techniques used in this research: cropping image, preprocessing, Quadrant Ballon Snake and identification. The first step is to crop image on metaphysis and epiphysis bone. The second step is preprocessing using morphology and edge detection. The third step is to apply Quadrant Ballon Snake to segment hand wrist bone. The last step is to use ratio metaphysis and epiphysis to indentify person. The performance segmentation for assessment hand wrist bone showed an average age identification 91%, bone age metaphysis 95% and bone age epiphysis 95%. The experiments resulted in the fact that Quadrant Ballon Snake method is able to find and improve the segmentation of hand wrist bone images accurately. This indicates that this method is effective for segmenting hand wrist bone.

Keywords: paper hand wrist bone, human forensic, cropping image, morphology, Quadrant Ballon Snake

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1. Introduction

Many accidents happen, but the identity of the victim is unrecognizable. Victim identities can be identified by using forensic identification. Forensic doctors identify victims using teeth, fingerprints and wrist bones. Identification using a wrist bone produces the most accurate identification [1]. Forensic doctors use the bone of the hand to know the age of a person. Forensic physicians determine the age of a person using epiphyseal and metaphysical bones. The results of identification can be compared using reference from Greulich and Pyle [2]. Forensic physicians using manual methods take a long time.

People die in mass disasters is very difficult to recognize his body [3]. This incident is very difficult to show evidence of birth date so it is very difficult to collect investigation data. Hand wrist bone can be used to estimate age. The bone of the wrist can provide reliable information because the structure of the bone is not easily damaged.

Previous research has been studied in bone assessment automatically [4]. This study can show age identification quite well by comparing references directly. In practice, the identification of the hand wrist bone structure is very difficult to achieve because the bone is easily damaged by impact, like a state of natural disaster.

In this paper, human forensic identification with the hand wrist bone is proposed. The bone structure of the wrist is shown in Figure 1. This method has several advantages. First, this method provides a simpler way than using the entire bone structure of the hand. Second, the hand wrist bone structure is relatively reliable because these bones are often undamaged. Third, the identification of a person's age can be done automatically.

Age identification can be recognized automatically by changing the x-ray color image to a gray scale. The bone structure of the wrist is extracted features of a gray scale image. Two active contour balloon models are used for epiphyseal and metaphysical bone segmentation. Active contours can be used well on noise-filled images. However, the contour with a concave shape is very difficult to recognize by the active contours. Therefore, the balloon model can be used to predict the concave contours [5]. This model can minimize the energy for contours to grow. The iteration will stop when the final contour has the highest energy [6,7]. Our method shows relatively well to automatic identify person age using hand-wrist bone structure.

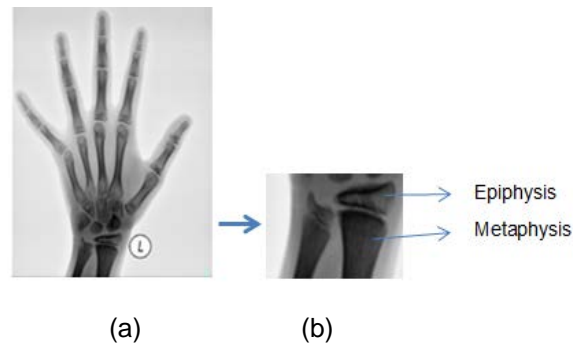


Figure 1. The bone structure of the wrist. (a) X-ray image and (b) hand wrist part

The related work is Forensic Age Estimation (FAE) is a new science in forensic field. The Roman Empire assigned young men to military service [8] in the nineteenth century. Age is estimated by dentists and dental eruption is considered a reliable method for detecting child's age. In 1846, Pedro Mata expressed his concern about estimating age based solely on teeth eruption [9]. Angerer was the first to suggest that carpus bone in the hand was an indicator to estimate age in young people [10].

Nurpadmi et al. [11] implements bone image segmentation using an active contour model. Zinah Rajab Hussein et al. [12] applied a preprocessing contraction extraction to a noisy ecocardiography image. In recent years, the active contour model introduced by Kass, has now grown rapidly. The balloon model [13] is one such example. In contrast to traditional snakes that shrink wrap around the image boundary, this snake model is expanding out. This model is based on additional inflationary forces applied to provide stable results. The active contour model that is not close to the contour is not interested in it. The curve behaves like a balloon soaring. When it passes the edge, it will not get stuck by a fake edge and just stop when the edges are strong.

This study proposes a new segmentation method that is Quadrant Ballon Snake. The first step is to crop image on metaphysis and epiphysis bone. The second step is to use morphology to eliminate noise. The third step is to apply Quadrant Ballon Snake to segment hand wrist bone. The last step is to use ratio metaphysis and epiphysis to identify person. It is believed that this technique can detect the boundary of bone age image very precisely.

2. Research Method

There are various methods and algorithms for age identification via hand wrist bone [1], [7]. In this study identification of age through hand wrist bone using Quadrant Ballon Snake. The method which involves cropping images, morphology and edge, Quadrant Ballon Snake and Identification are graphically described in a schematic diagram shown in Figure 2.

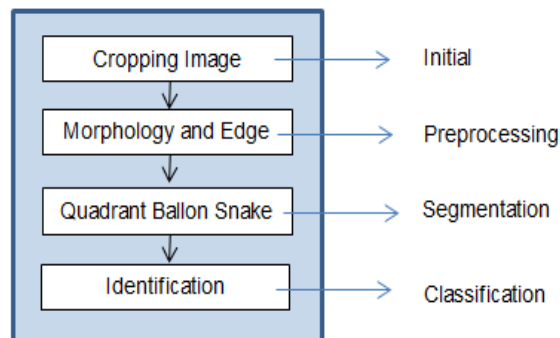


Figure 2. Schematic diagram of the Algorithm

2.1. Cropping Image

The first step is to crop image on metaphysis and epiphysis bone. In this study, metaphysis and epiphysis bone in the right wrist bone was used to determine age. Metaphysis and epiphysis bones are trimmed from the right wrist bone using cropping techniques.

In this study, the cropping image using a rectangular shape. This process is used to perform initial segmentation of the metaphysis and epiphysis bones. Figure 3 shows the results of cropping image on metaphysis and epiphysis bones.

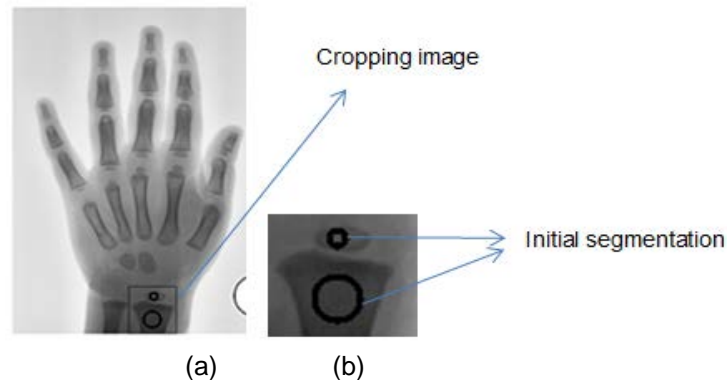


Figure 3. (a) Hand bone image (b) cropping image

2.2. Morphology and Edge Detection

The second step is pre-processing using morphological filters and edge detection. Morphology can reduce noise and clarify the image boundary. In morphology, the image is expressed as a set of discrete coordinates. Morphological operations use two inputs, namely the original image and structure.

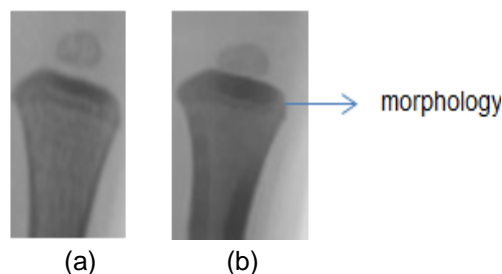


Figure 4. (a) Original image (b) Dilation operation

The edge detection method is using canny. Canny algorithm approach was done by convolution function image with a structuring element of morphology and their derivatives. Figure 4 below shows the result of dilation operation from hand-wrist image to reduce the noise and to detect edge as shown in Figure 5.

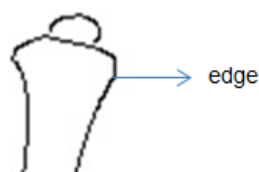


Figure 5. Canny edge detection

2.3. Quadrant Balloon Snake

The third step is to apply Quadrant Balloon Snake to segment hand wrist bone. This method is advanced from snake model. Figure 6 below shows a mathematical model of energy snakes, where E_{int} , E_{image} and E_{con} represented the internal and external energy from active contour models.

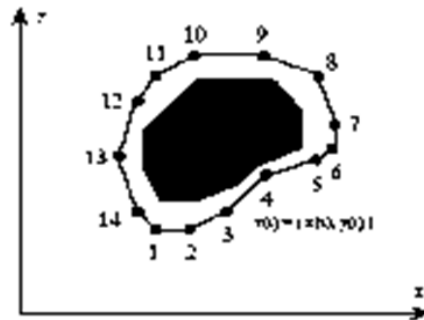


Figure 6. Mathematical model of energy snakes

Mathematical model of energy snakes, where E_{int} , E_{image} and E_{con} represented the internal and external energy from active contour models. Parameter active contour sets of coordinate points on contour controlled can be defined on equation 1 below:

$$\vec{v}(s) = (\vec{x}(s), \vec{y}(s)) \quad (1)$$

Where $x(s)$ and $y(s)$ is the x and y coordinates on the contour and s is the normalized index of the control points. Energy function described active contour consists of two components is the internal energy and external energy. Internal energy makes compact curve (elastic force) and a very sharp turn limits (bending force). External energy tends to make the curve moves to the object boundary [9-10].

Internal energy as the sum of the elastic energy and energy resiliency can be expressed on equation 2 below:

$$E_{int} = E_{elastic} + E_{bend} = \alpha(s) \left| \frac{dv}{ds} \right|^2 + \beta(s) \left| \frac{d^2v}{ds^2} \right|^2 \quad (2)$$

Where $\alpha(s)$ is continuity function (stretching) and $\beta(s)$ is functions of bending. External energy limits the deformability of curve, the restrictions provided by the external energy can take various forms including the spring and repulse. In effect, external energy has never been used because every form of external energy has certain purpose.

Snakes energy has equation that sum internal energy and external energy which is shown on equation 3 below:

$$\begin{aligned} E_{snake} &= \int_0^1 E_{snake}(v(s)) \cdot ds \\ &= \int_0^1 \{E_{int}(v(s)) + E_{image}(v(s)) + E_{con}(v(s))\} \cdot ds \end{aligned} \quad (3)$$

Where $v(s)$ is coordinate values ($x(s)$, $y(s)$), with the value $s=0,1$, E_{int} is internal energy, E_{image} is image force and E_{con} is external energy. The results obtained from the gaussian operation of hand-wrist image to polish the object research. The boundary process can be done by alpha, beta and gamma parameter.

In this research, movement energy using quadrant cartesian can be used to movement of baloon models. First step, calculation of points forming the circle uses the formula of circle which is shown on Equation 4:

$$\text{Distance} = \sqrt{(x_1 - x_0)^2 + (y_1 - y_0)^2} \quad (4)$$

The second step is calculation of the distance used as the radius of the circle to make a point of initials into a circle with a number of points as much as 360 circle axis 360 ° fit. Calculation of distance which shown on equation 5 and 6:

$$x = \text{center}_x + \text{distance}(x_1, y_1, x_0, y_0) * \cos\left(\frac{360 * \pi}{180}\right) \quad (5)$$

$$y = \text{center}_y + \text{distance}(x_1, y_1, x_0, y_0) * \sin\left(\frac{360 * \pi}{180}\right) \quad (6)$$

When: x0 and y0 is first midpoint, x1 and y1 is second point

The third step is perform energy movement with gradient energy and quadrant cartesian rules. To run the energy gradient by gamma value can elaborated the formula which shown on equation 7 below:

$$\begin{aligned} E_{\text{ext_gradient}} &= -\gamma \sum_{i=0}^{n-1} (|G_x(x_i, y_i)|^2 + |G_y(x_i, y_i)|^2) \\ &\Leftrightarrow -\gamma \sum_{i=0}^{n-1} (|u_{x,i} G_x(P_i) + u_{y,i} G_y(P_i)| \\ \vec{u}_i &= \frac{\vec{P}(t_i)}{|\vec{P}(t_i)|} \quad \Leftrightarrow -\gamma \sum_{i=0}^{n-1} \vec{u}_i \cdot \vec{G}_y(P_i) \end{aligned} \quad (7)$$

The fourth step is finding the minimum energy of the boundary on the other border of the contour. In this method, quadrant cartesian and ballon snake can be used to deformable curve the contour as shown in Figure 7.

2.4. Identification

Part of the determination of age i.e. the ratio of the width of the metaphysis and epiphysis based on the widest distance on x-axis. Calculation of the width of the search with the difference in the value of x with the following formulation.

- Do the initialization point and midpoint edge on the metaphysical and the epiphysis bone image described at equation 4.
- From the initials points of each image of the bones is referred to as the fingers to increase point form a circle. So the 2 initial starting point would be the appropriate point with an area of 360 full circle=360° with a formula that has been spelled out in eq.5 and 6.
- Provide a limit value of x1 and x2 is where the value of x1 as the value of the smallest width x or x < 0 and the value of x2 as the value of largest width or x > 0. So the calculation of the difference in width x is x2-x1.
- The width data of result is compared to reference data to determine the age.

3. Results and Discussion

Before segmentation object of bone age only on metaphysis and epiphysis, there is one step that must be done is to determine the starting point iteration for the movement active contour models method. Table 1 shows the effect of initial iteration on the movement from active contour models method and result of object segmentation.

From the Table 1, it can be seen that if we use 25 number of iteration, we will get better segmentation on the metaphysis and epiphysis bone. In the 25 number of iteration produce width of the metaphysis and epiphysis which reaches nearly all edge of the bone that is 1.28019cm: 0.434783cm with the time is 209 387 seconds or nearly 4 minutes.

Table 1. Comparison between Number of Iterations and Result Object Segmentation


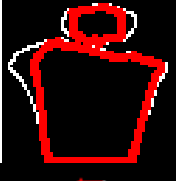

Testing	Number of iterations	Result of segmentation	Ratio (cm)	Time (second)
1.	1		0.57971 : 0.31401	25.7768
3.	10		1.08696 : 0.434783	105.63
5.	25		1.28019 : 0.434783	209.387



Figure 8. Movement by active contour models step by step

Result of the movement in the Figure 8 caused quadrant position of the x and y every points that has been initialized in the first active contour models process. When all of the points. Testing identification of age based on the ratio width of the x coordinates. In the table 2 shows testing system with the 5 x-ray images of the patient's data.

Table 2. Testing System with Bone Age of Patient's Data

Age	X-ray File	Testing	Success (%)
3 years old	3th.bmp	5 data, 5 success	100 %
4 years old	4th.bmp	2 data, 2 success	100 %
6 years old	6th.bmp	5 data, 4 success	80 %
9 years old	9th.bmp	4 data, 3 success	75 %
13 years old	13th.bmp	3 data, 3 success	100 %

From the Table 2., it can be analyze that not all points will still on the edge of metaphysis and epiphysis bone. All of the points will move if there is not found edge in the bone's area. That is because of hand-wrist bone images not clearly. So, if we will get better segmentation every images must be set different threshold value and kernel of morphology. The average percentage of the system's success is 91% with 19x-ray images of the hand-wrist bone. This system is successfully identified 17 data that matched with age on x-ray image and 2 data errors. Comparison average width of a metaphysis and epiphysis between system and reference as shows in Table 3 and 4.

Table 3. Comparison Average Width of a Metaphysis between System and Reference

Age	Reference (cm)	System (cm)	Deviation (cm)	STD (5 testing)
3 years old	1,8	1,5942	0,20580	0,08191
4 years old	2,05	1,8116	0,23840	0,05124
6 years old	2,2	1,82125	0,3787	0,02160
9 years old	2,25	1,82609	0,42391	0,01323
13 years old	2,5	1,71498	0,78502	0,04184

Table 4. Comparison Average Width of a Epiphysis between System and Reference

Age	Reference (cm)	System (cm)	Deviation (cm)	STD (5 testing)
3 years old	1,2	0,700483	0,4995166	0,0241545
4 years old	1,55	1,19807	0,35193	0,5168203
6 years old	1,85	1,52657	0,32343	0,2552865
9 years old	2,15	1,487924	0,662076	0,169598
13 years old	2,7	1,599034	1,100966	0,133835

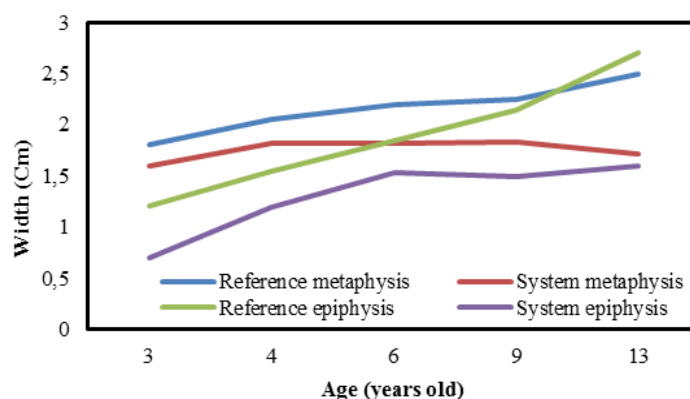


Figure 9. Chart of comparison metaphysis epiphysis between system and reference

From the figure 9 shows that in the 3 years until 10 years old have a small difference width reference and system that is 0.06 up to 0.4 on the metaphysis's width and the difference epiphysis's width is 0.02 up to 0.9. This indicates that this method is effective to identification age from x-ray image of hand-wrist bone.

4. Conclusion

The proposed method presents solution for human forensic identification with hand wrist bone using active contour model. The proposed system gives an accuracy of 91% for age identification, 95% for bone age metaphysis and 95% for bone age epiphysis.

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